

Text table 1-2.

**Federal R&D appropriations for Fiscal Year 1952**

Agency	Amount of U.S. dollars (in millions)		Percent	
	1952 current	1998 constant	Total	Non-DOD
<b>Department of Defense (DOD)</b> .....	890.0	5,071.6	70.6	
<b>Non-DOD</b> .....	370.2	2,109.5	29.4	100.0
Atomic Energy Commission .....	162.9	928.3	12.9	44.0
Public Health Administration <sup>a</sup> .....	38.5	219.4	3.1	10.4
National Advisory Committee for Aeronautics .....	49.4	281.5	3.9	13.3
National Science Foundation .....	1.1	6.3	0.1	0.3
Agriculture Department .....	51.7	294.6	4.1	14.0
Commerce Department .....	15.4	87.8	1.2	4.2
Interior Department .....	31.9	181.8	2.5	8.6
Other .....	19.3	110.0	1.5	5.2
<b>Total</b> .....	<b>1,260.2</b>	<b>7,181.1</b>	<b>100.0</b>	

NOTE: Details may not sum to totals because of rounding.

<sup>a</sup>Includes National Institutes of Health.SOURCE: National Science Foundation, *Second Annual Report* (Washington, DC: U.S. Government Printing Office, 1952).

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total budget for that year also included \$1.53 million for graduate and post-doctoral fellowships. The remaining funds were allocated for administration, and for miscellaneous activities, including scientific translations.

Despite the fact that its R&D appropriation for FY 1952 was \$1.1 million, compared with the total Federal R&D budget of more than \$1.2 billion, NSF already occupied a unique position in the Federal system. It was—and remains—the sole agency chartered to support research and education across all fields of science and engineering. In addition, Congress expected NSB, its policymaking body, to deal with issues transcending the Foundation's programmatic mission. Among other things, NSF (by law the National Science Board and Director) was “authorized and directed” to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences; ... to foster the interchange of scientific information among scientists in the United States and foreign countries; and ... to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups.”<sup>14</sup>

The evolution of the Board's involvement in monitoring the state of science and engineering, culminating with the transmission of the first *Indicators* report (NSB 1973) to President Richard M. Nixon in 1973, is discussed in “Monitoring the Condition of the Science and Engineering Enterprise.”

## Early Visions/Key Policy Documents

Both the size and complexity of the U.S. science and engineering enterprise have grown substantially since the creation of NSF. Despite this, a striking continuity with the present is discernible in the visions of science–government relations that

emerged in the immediate aftermath of World War II. These early visions were encapsulated in two key policy documents: *Science—The Endless Frontier* (July 1945) and *Science and Public Policy* (August 1947). Although differing in many respects, both reports emphasized the need for a strong commitment to genuine partnerships and linkages among the industrial, academic, and Federal Government research sectors, a commitment that is among the unique strengths of the U.S. system.

### *Science—The Endless Frontier* (1944–45)

The impetus for *Science—The Endless Frontier*, as already noted, was a letter addressed to Vannevar Bush by President Franklin D. Roosevelt on November 17, 1944, 10 days after President Roosevelt's reelection to an unprecedented fourth term. The President's letter asked for advice on how lessons learned from the mobilization of science and engineering during World War II might be used in peacetime “for the improvement of the national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living” (Bush 1945a, 3).

### *Creation of the Office of Scientific Research and Development*

That the President would seek guidance on these matters from Vannevar Bush, who was director of the wartime Office of Scientific Research and Development (OSRD) was natural enough, since Bush had been serving as his *de facto* science advisor for more than a year before the United States entered World War II in December 1941. On June 12, 1940, seven days after the German army invaded France, Bush, president of the Carnegie Institution of Washington and a former Dean of Engineering at the Massachusetts Institute of Technology (MIT), met with the President to propose that he should

<sup>14</sup>Public Law 81-507, Section 3(a).

create a National Defense Research Council (NDRC). NDRC's charge would be to explore, in detail, the problem of organizing the Nation's scientific resources in preparation for what both men were certain would be the inevitable entry of the United States into what was still primarily a European conflict. Roosevelt accepted this proposal, naming Bush chairman of NDRC.<sup>15</sup>

A year later, Roosevelt decided that the rapidly escalating military crisis abroad required the creation of an agency with broader authority than NDRC. Accordingly, in June 28, 1941, he issued an executive order creating OSRD within the Executive Office of the President, stating that OSRD was to:

... serve as a center for mobilization of the scientific personnel and resources of the Nation in order to assure maximum utilization of such personnel and resources in developing and applying the results of scientific research to defense purposes ... [and] to coordinate, aid, where desirable, supplement the experimental and other scientific and medical research activities relating to national defense carried on by the Departments of War and Navy and other departments and agencies of the Federal Government.<sup>16</sup>

NDRC, chaired by James B. Conant, was retained as one of two components of OSRD; a Medical Research Committee was created as its other component.<sup>17</sup>

OSRD was authorized to mobilize the Nation's science and engineering resources for the impending entry of the United States into World War II. To do so, Bush and his senior colleagues faced the formidable tasks of working with appropriate staff in the Departments of War and Navy to identify and establish priorities for defense-related research projects; identifying and assembling the scientists and engineers capable of dealing with those projects; providing them with the resources they required; and finally ensuring that their results moved expeditiously into wartime production.

### *The Prewar U.S. R&D Enterprise*

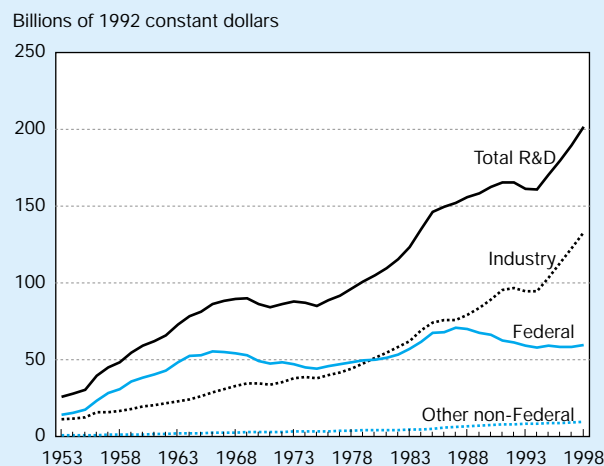
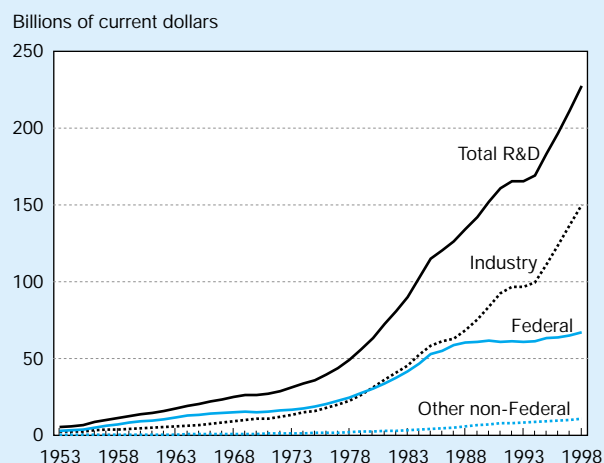
While the science and engineering resources available to OSRD were reasonable, they were also scattered. By 1940, the three sectors that still account for most of the Nation's research performance—industrial, government, and academic—were already well established. However, their relative importance and the relationships between them differed from what they are today. Then as now, industry was the principal supporter and performer of R&D. A total of \$345 million was estimated to have been expended for R&D in the United States in 1940, with industry investing \$234 million,

or almost 68 percent of this amount.<sup>18</sup> Although industrial investments were roughly the same proportion of total national expenditures as at present, from 1951 (the first full year of the Korean War) until 1980, industry's share of total national R&D expenditures was less than that of the Federal Government. (See figure 1-1 and text table 1-3.)

In 1940, the Federal Government ranked a distant second, expending an estimated \$67 million for R&D, or less than 20 percent of total national R&D expenditures, during that same year. In fact, Federal R&D expenditures in 1940 were only slightly more than twice the \$31 million expended by universities and colleges. The remaining \$13 million was accounted for by state governments, private foundations and research institutes, and nonprofit industrial research institutes. No reliable prewar data are available on R&D performance expenditures. However, it is reasonable to assume that the bulk of the industrial and Federal Government expenditures went to

<sup>18</sup>R&D expenditure estimates are given by Bush (1945a, app. 3, 86) and Steelman (1947, vol. I, 10).

Figure 1-1.  
National R&D funding, by source: 1953–98



See appendix tables 2-5 and 2-6.

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<sup>15</sup>Other NDRC members included James B. Conant, president of Harvard University (and later the first chairman of NSB); Karl T. Compton, president of MIT; and Frank B. Jewett, president of the National Academy of Sciences and chairman of the board of the Bell Telephone Laboratories.

<sup>16</sup>Executive Order 8807, "Establishing the Office of Scientific Research and Development in the Executive Office of the President and Defining Its Functions and Duties."

<sup>17</sup>When OSRD was abolished at the end of 1947, the contracts that its Medical Research Committee still retained with several of the Nation's medical schools were turned over to NIH. These transfers initiated the transition of NIH from an agency that had previously supported research primarily in its own laboratories, to one of the world's foremost supporters of biomedically related research, as well as the Federal agency with the largest basic research budget.

Text table 1-3.

**Estimated R&D expenditures, by source for selected years**

Expenditures (in millions)	Total	Industry	Federal	Universities and colleges	Other <sup>a</sup>
1940 current dollars .....	345	234	67	31	13
1998 constant dollars .....	3,617	2,453	702	325	136
Percent of total .....	100	67.8	19.4	9.0	3.8
1947 current dollars .....	1,160	450	625	45	40
1998 constant dollars .....	7,645	2,966	4,119	297	264
Percent of total .....	100	38.8	53.9	3.9	3.4
1957 current dollars .....	9,908	3,470	6,233	51	155
1998 constant dollars .....	50,345	17,629	31,669	259	788
Percent of total .....	100	35.0	62.9	0.5	1.6
1967 current dollars .....	23,346	8,146	14,563	200	439
1998 constant dollars .....	99,326	34,655	61,957	849	1,866
Percent of total .....	100	34.9	62.4	0.9	1.9
1977 current dollars .....	43,456	19,645	22,155	569	1,089
1998 constant dollars .....	103,258	46,678	52,642	1,351	2,586
Percent of total .....	100	45.2	51.0	1.3	2.5
1987 current dollars .....	126,255	62,683	58,548	2,262	2,762
1998 constant dollars .....	171,309	85,052	79,441	3,069	3,747
Percent of total .....	100	49.6	46.4	1.8	2.2
1998 current dollars .....	227,173	149,653	66,930	4,979	5,611
Percent of total .....	100	65.9	29.5	2.2	2.5

NOTE: Details may not sum to totals because of rounding.

<sup>a</sup>Includes state governments and nonprofit institutions.

SOURCES: For 1940, Vannevar Bush, *Science—The Endless Frontier: A Report to the President on a Program for Postwar Scientific Research* (1945a). Reprinted by NSF (Washington, DC: 1990). For 1947, John R. Steelman, *Science and Public Policy* (Washington, DC: U.S. Government Printing Office, 1947). Reprinted by Arno Press (New York: 1980). For 1957–98, National Science Foundation, *National Patterns of R&D Resources*. (Arlington, VA: biennial series).

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support R&D in their own respective facilities, whereas all academic expenditures for this purpose supported academic research.

Despite the absence of reliable data, it is widely acknowledged that a good deal of academic research prior to World War II qualified as applied research according to current definitions. Additionally, academic research, whether basic or applied, was concentrated in a relatively small number of institutions. According to *Science—The Endless Frontier*, during the 1939/40 academic year, 10 of the estimated 150 research universities in the United States performed \$9.3 million or 35 percent of the total \$26.2 million in research performed in the natural sciences and engineering by the academic sector, while 35 of these 150 universities performed \$16.6 million or 63 percent of the academic total (Bush 1945a, 122).

Prior to World War II, institutional partnerships among the Nation's three research sectors were the exception rather than the rule. Department of Agriculture programs that had supported research in the Nation's land grant colleges since the late 19th century constituted one prominent set of exceptions. Precedents set by the National Advisory Committee on Aeronautics (NACA), the predecessor of the National Aeronautics and Space Administration (NASA), were more pertinent to the OSRD system. NACA, which was created in 1915 and

consisted of representatives from both the Federal Government<sup>19</sup> and industry, operated facilities that conducted R&D related to problems of civil and military aviation. The bulk of NACA's research was conducted in these in-house facilities, which were taken over by NASA when the latter agency was created in 1958. However, during the 1920s, NACA also began to award occasional contracts to university engineering schools. In 1939, it had 12 contracts with 10 universities (Dupree 1957, 366).

With these exceptions, the Federal Government provided no support for university research prior to 1941. Faculty in university science and engineering departments occasionally worked in their private capacities as consultants to Federal research bureaus. But any suggestion that the Federal Government should initiate an openly available program to fund university research on no grounds other than its intrinsic merit would have been considered an unwarranted intrusion into the affairs of those institutions. Rather, research in the academic sector was supported by income on endowment (in the case of private universities); by state funds (in the case of public universities); by grants from private, nonprofit foundations such as the Carnegie Corporation, the Rockefeller

<sup>19</sup>One of the original Federal Government members of NACA was Franklin D. Roosevelt, then serving as Assistant Secretary of the Navy in the Wilson Administration.

Foundation, and the Commonwealth Fund; and on occasion by private industry.

### **The OSRD System**

The OSRD system was collegial and decentralized. Rather than electing to become a scientific “czar” who would centralize and control all aspects of the wartime research effort, Bush assumed the roles of buffer and arbitrator between the scientists and engineers engaged in wartime research and the Federal Government’s technical bureaus, particularly those in the Departments of War and Navy. During World War I, many of the scientists and engineers who had engaged in defense research were given temporary military commissions, then sent to work at existing defense laboratories (Dupree 1957, 302–25). In contrast, the OSRD system was based on the novel assumption that, except in very special cases, research could best serve wartime needs if scientists and engineers continued in their civilian status and worked in settings where research was carried out in peacetime—be they academic or industrial. That is, industrial and academic organizations worked in partnership with the Federal Government rather than under its direct control. Because Bush enjoyed direct access to President Roosevelt, he was able to convince him (although not all the old line Federal scientific bureaus) that this decentralized system would be more effective in achieving the desired result of adapting U.S. scientific resources rapidly for national defense purposes than a system based on the World War I model.

In fact, the system was superbly effective. Radar was developed and refined at the Radiation Laboratory at MIT by scientists and engineers brought there from several institutions. The Oak Ridge, Tennessee, facility, where the rare, fissionable isotope of uranium ( $^{235}\text{U}_{92}$ ) was separated, was managed by the General Electric Company. Even the ultra-secret Los Alamos, New Mexico, laboratory, where the R&D leading to the first nuclear bombs was performed, was managed by the University of California under a contract with the Army rather than directly by the Federal Government.

Following its creation in 1946, AEC took over from the Army its management contracts with the General Electric Company, the University of California, and several other organizations that had managed these World War II facilities, and the facilities themselves came to be known as Federally funded research and development centers (FFRDCs). Many are still managed by the same academic or industrial organization that managed them during World War II through contracts with the Department of Energy. Additional FFRDCs have been created since World War II, some of which, such as the Fermi National Accelerator Laboratory in Batavia, Illinois, and the Stanford Linear Accelerator Center (SLAC), house large-scale facilities where basic research is conducted by university-based user groups.<sup>20</sup>

<sup>20</sup>Other agencies, including the Department of Defense and NASA, also support FFRDCs through contracts with nongovernment organizations; cf. NSB (1996a, 4-26–4-29).

Wartime experiences had demonstrated the potential for productive partnerships among the Nation’s principal research sectors. They also demonstrated the importance of university scientists (and thus, by implication, the academic sector) in conceptualizing and demonstrating the feasibility of novel, often risky research ideas—such as many of the concepts underlying radar and nuclear weapons. Additionally, they suggested that, even in wartime, the effective conduct of research required that science be insulated, as much as possible, from conventional political processes. These experiences conditioned the vision articulated by *Science—The Endless Frontier*.

### **Responding to Roosevelt**

President Roosevelt’s November 1944 letter to Bush on the peacetime implications of lessons learned from the World War II mobilization of science and engineering requested responses to four questions. These questions dealt with (1) the expeditious declassification of secret wartime research results, (2) the need to develop a program to support health-related research, (3) conditions through which the government could provide aid to research activities in public and private organizations, and (4) the feasibility of creating a program for discovering and developing scientific talent. To address the President’s request, Bush convened four committees consisting primarily of distinguished nongovernment scientists and engineers, charging each committee to prepare a report, with recommendations, on one of President Roosevelt’s four questions.<sup>21</sup> Bush’s own 40-page synthesis of the resulting committee reports constituted the body of *Science—The Endless Frontier* (Bush 1945a); the four committee reports, each consisting of an in-depth response to one of the President’s questions, appeared as appendices.

Bush and his committees carried out their assigned tasks during months of mounting exuberance. By the time *Science—The Endless Frontier* was submitted to President Truman in July 1945, World War II was drawing rapidly to a close. Germany had surrendered on May 8, the first nuclear weapon was due to be tested on July 16, and the defeat of Japan was all but assured—even though informed military opinion estimated that another year and as many as 1 million American casualties would be required. The United States and its allies had achieved military supremacy, and science and engineering had made indispensable contributions to that outcome.

Bush and his colleagues welcomed the opportunity to take the lead in planning for the future and, in particular, to capitalize on the recognition that the importance of academic research had received in the OSRD system. However, they insisted that any government program to organize science for peacetime purposes had to be consistent with the traditional norm of scientific autonomy that, to a remarkable extent, had

<sup>21</sup>These were the Medical Advisory Committee, chaired by W.W. Palmer, Bard Professor of Medicine, Columbia University; the Committee on Science and the Public Welfare, chaired by Isaiah Bowman, president of The Johns Hopkins University; the Committee on Discovery and Development of Scientific Talent, chaired by Henry Allen Moe, secretary-general of the Guggenheim Foundation; and the Committee on Publication of Scientific Information, chaired by Irvin Stewart, executive assistant to the director of OSRD and later president of the University of West Virginia.

remained largely intact during the wartime years (Reingold 1987; Blanpied 1998).

### **A National Research Foundation**

Bush and his four committees seized the opportunity provided by President Roosevelt's November 1944 letter to advance what could only be regarded at that time as a bold and innovative proposition. Simply stated, *Science—The Endless Frontier* argued that the Federal Government had not only the authority, but also the *responsibility*, to ensure a continued supply of research results by (1) supporting research in nonprofit institutions—primarily, although not exclusively, basic research in universities—and (2) offering scholarships and fellowships to aspiring scientists and engineers.<sup>22</sup> An essential element of the report's proposition that the Federal Government should support research in nonprofit organizations was its insistence that the support should be provided solely on the basis of scientific merit, as judged by those with the necessary professional experience and background to make that determination. "It is my judgment," Bush wrote, "that the national interest in scientific research and scientific education can best be promoted by the creation of a National Research Foundation" (Bush 1945a, 34).<sup>23</sup> The new responsibilities envisioned for the Federal Government were too novel and too important to be entrusted to any existing agency. The final paragraph of *Science—The Endless Frontier* stressed that early action by Congress to create the National Research Foundation was "imperative" (Bush 1945a, 40).

In keeping with his wartime experiences, Bush recommended that the new agency should be isolated as much as possible from conventional political processes. Its board of directors (or what *Science—The Endless Frontier* referred to as its "members") would be appointed by the President and would consist of "citizens selected only on the basis of their interest in and capacity to promote the work of the agency. They should be persons of broad interest in and understanding of the peculiarities of scientific research and education" (Bush 1945a, 33). The National Science Foundation Act of 1950 adhered to this dictum by legally defining NSF as a Director and a National Science Board to consist of 24 members "eminent in the fields of basic sciences, medical science, engineering, agriculture, education, and public affairs."<sup>24</sup>

### **Promotion of Research in Industry**

The line of reasoning that *Science—The Endless Frontier* presented in arriving at its centerpiece recommendation is worth reviewing, since it was to become a major foundation of U.S. science policy for many years. In keeping their own *laissez-faire*, free-market philosophy, Bush and his colleagues were adamantly opposed to any Federal Government inter-

ference with the prerogatives of private industry, except in the area of national defense. Industry alone, they argued, was equipped to determine which basic research results in the public domain were worth exploiting for possible commercial purposes and how they should be exploited. This position was summarized in a familiar passage from *Science—The Endless Frontier*, namely, that "The most important ways in which the Government can promote industrial research are to increase the flow of new scientific knowledge through support of basic research, and to aid in the development of scientific talent" (Bush 1945a, 7).

Prior to World War II, the large majority of the basic research results that industry required were foreign imports, primarily from Europe. But European research capabilities had been devastated by World War II. Therefore, the Bush report argued, the United States would henceforth have to assume primary responsibility for obtaining its own basic research results.

### **Centrality of Universities**

*Science—The Endless Frontier's* central proposition that Federal science policy should focus on the support of research in nonprofit institutions (mainly colleges and universities) strongly if implicitly suggested that universities, which prior to World War II were on the periphery of the U.S. research system, should be thenceforth regarded as occupying its vital center. This line of argument was persuasive; much of the most innovative wartime research had been carried out in university or quasi-university settings by university scientists and engineers. With the partial exception of the United Kingdom, no other country had had a similar experience. As one result, the postwar emergence of universities as the primary performers of basic research has been virtually unique to the United States.

### **Other Issues**

*Science—The Endless Frontier* was never intended to be a complete blueprint for U.S. science policy. In fact, much of its enduring impact is explained by the fact that it focused on a few key ideas and advanced them persuasively. The most enduring of those ideas are in the category that would later be referred to as "policy-for-science": that is, issues having to do with funding levels, sources, incentives, and priorities for research, and the development and utilization of human resources for science and engineering, for example.

In contrast, considerably less attention was paid to issues in the "science-for-policy" category—those concerned with the uses of scientific knowledge and capabilities for governance or, more broadly, in the service of the larger society. *Science—The Endless Frontier* did recognize the vital importance of science to society; its opening paragraphs state emphatically that "without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world" (Bush 1945a, 5). Additionally, adequate responses to President Roosevelt's queries, such as declassification of wartime re-

<sup>22</sup>Bush was familiar with the legislation to create a National Science Foundation that had been introduced by Senator Kilgore in 1944, which was a revised version of an earlier 1943 bill. In fact, Kilgore had sought Bush's advice on certain aspects of its revision (Kevles 1977).

<sup>23</sup>Soon after the start of congressional hearings in October 1945, the name National Science Foundation rather than National Research Foundation was adopted for the proposed agency. See England (1983).

<sup>24</sup>Public Law 81-507, Section 4(a).

search results, required specific science-for-policy recommendations. Finally, the report stressed the desirability to “coordinate where possible research programs of utmost importance to the national welfare” (Bush 1945a, 31), but offered few hints on how that might be accomplished other than through a nongovernmental oversight and advisory committee.

Several of these themes and issues considered by *Science—The Endless Frontier*, such as those that addressed the President’s first question on the declassification of wartime research results, are now of little interest save to students of the postwar period. Others retain their currency, even though their context has changed considerably. These include the following:

- ♦ integration of defense research into the overall national system,
- ♦ human resources for science and engineering,
- ♦ research in Federal mission agencies,
- ♦ tax and patent policies, and
- ♦ international exchange of scientific information.

These and other issues were also treated, often at greater length, in *Science and Public Policy*—which was intended to be both a policy-for-science and science-for-policy document—when it was prepared beginning in late 1946. They are thus identifiable as among the principal science policy themes during the first time of transition, as discussed below.

### Use of Data

Although Bush included an occasional quantitative reference in the body of *Science—The Endless Frontier*, he relied almost entirely on his wide experience and his persuasive rhetoric, rather than on data-based analysis, to press his case for a National Research Foundation. The four appended committee reports relied more heavily on data. They included, for example, tables listing national research expenditures from 1920 to 1944 and details of research expenditures in selected university departments and companies (Bush 1945a, 123, 127–9). Human resources data included numbers of Ph.D.s awarded by the scientific field from 1935 (Bush 1945a, 177–9). Several related tables, referred to, collectively, as the education pyramid, provided data on enrollments in educational institutions from primary grades through college and graduate school for all students, but with no breakdown for enrollments in science (Bush 1945a, 166–76). These data provided a basis for arguing that too many otherwise able students were being lost to higher education because of their inability to pay the required costs so that the provision of Federal Government-supported scholarships and fellowships, based on academic promise, would be in the national interest.

That the bulk of the data contained in the committee reports predated 1941 provides a clue to why *Science—The Endless Frontier* contained relatively little quantitative information: namely, the wartime conditions prevailing in 1944–45 precluded the provision of the resources that would have

been necessary to conduct the studies that would have been needed to obtain a more detailed, quantitative picture of the U.S. science and engineering enterprise. Additionally, financial and human resources data considered critical to national mobilization would almost certainly have been classified. After the war ended, it was possible once again to collect and/or declassify data on various aspects of U.S. society, including those related to science and engineering. Many of these categories of data were compiled and analyzed in the August 1947 report of the President’s Scientific Review Board entitled *Science and Public Policy* (Steelman 1947).

## Science and Public Policy (1946–47)

### Context

In November 1944 when President Roosevelt addressed his four questions to Vannevar Bush, only he and a handful of OSRD colleagues, a few members of Congress and their key staff, along with several officials in BoB, had given much serious thought to issues of science and government in the postwar era (Kevles 1977). Within the next two years, the rapidly increasing significance of the Federal Government’s role in science and engineering had become obvious, as had the impact of Federal policies and actions on the industrial and academic research sectors.

Given the pervasive character of the Federal role, the BoB had become convinced by the end of 1945 that it required an institutionalized source of expert advice to assist it in its task of formulating and implementing science- and technology-related policies and programs. It believed that what by then was being referred to as a National Science Foundation, particularly what a pending congressional bill proposed as its governing board of eminent nongovernment presidential appointees, could provide the advice it required.

However, although the general idea of an agency to support research in nonprofit organizations, provide scholarships and fellowships, and serve as a source of policy advice attracted bipartisan congressional support, there were serious differences within the Congress and between the Congress and the Truman Administration on specific details, including the scope and administrative structure of the proposed agency. When, in June 1946, the 79th Congress adjourned before the House of Representatives had considered a Senate bill to create a National Science Foundation,<sup>25</sup> several BoB staff members, including Elmer Staats, William Carey, Willis Shapley, and Charles Kidd, began to explore other options to carry out the functions they had hoped a National Science Foundation and its Board would fulfill. Accordingly, they persuaded President Truman to issue an Executive Order on October 17, 1946, to create a President’s Scientific Research Board charged “to review current and proposed research and development (R&D) activities both within and outside of the Federal Government.”

<sup>25</sup>The failure of the 1946 legislation was the first of several failed attempts to reconcile conflicting views on the organization of the proposed agency that were to delay enactment of enabling legislation until May 1950 (England 1983, Blanpied 1998).



PSRB was chaired by John R. Steelman, director of the Office of War Mobilization and Reconversion within the Executive Office of the President, who on January 1, 1947, was appointed the Assistant to the President. Steelman, an economist who had helped settle two potentially crippling labor disputes early in 1946, enjoyed the confidence of, and ready access to, President Truman. Among his other duties, he oversaw and coordinated the work of the White House staff so that he became, in effect, the first White House Chief of Staff.<sup>26</sup>

### Scope and Content

The President's Executive Order had charged Steelman, as PSRB chairman, to submit a report:

... setting forth (1) his findings with respect to the Federal research programs and his recommendations for providing coordination and improved efficiency therein; and (2) his findings with respect to non-Federal research and development activities and training facilities ... to insure that the scientific personnel, training, and research facilities of the Nation are used most effectively in the national interest.<sup>27</sup>

The first volume of the PSRB's report, entitled *Science and Public Policy* and commonly referred to as the Steelman report, was published on August 27, 1947. Consistent with the President's charge, the report balanced considerations of policy-for-science and science-for-policy. The analysis, conclusions, and recommendations contained in the first 68-page summary volume, aptly entitled "A Program for the Nation," spanned the entire range of Federal and non-Federal science and technology activities, including the international dimensions of U.S. science policy. Much of the text was supplemented with imaginative graphics, which were used to support its arguments, conclusions, and recommendations. These were based on detailed, extensive data and analysis contained in the report's four succeeding volumes, all of which were released by the end of October 1947.<sup>28</sup>

Taken together, the Steelman report's five volumes compose what was by far the most complete and detailed description of the U.S. science and technology system (particularly its Federal component) that had been produced up to that time. The four background volumes of *Science and Public Policy*, in their extensive use of data and survey results (a good deal gathered specifically for the report), their analyses, and their use of charts, can be regarded as a precursor for what was to become, beginning in 1972, NSB's biennial series of *Science and Engineering Indicators* reports.

<sup>26</sup>Members of PSRB included the secretaries of all cabinet departments with significant science and technology programs, including War, Navy, Agriculture, Commerce, and Interior, as well as the heads of several noncabinet agencies, including NACA (the precursor of NASA), AEC, the Tennessee Valley Authority, the Veterans Administration, and importantly, Vannevar Bush as director of OSRD.

<sup>27</sup>Executive Order 9791, "Providing for a Study of Scientific Research and Development Activities and Establishing the President's Scientific Research Board" (Stelman 1947, vol. I, 70–1).

<sup>28</sup>The titles of the five volumes of *Science and Public Policy* (the Steelman report) were vol. I, "A Program for the Nation"; vol. II, "Science in the Federal Government"; vol. III, "Administration of Research"; vol. IV, "Manpower for Research"; and vol. V, "The Nation's Medical Research."

## Themes and Issues

### Research Expenditures

A unique feature of "A Program for the Nation," the first summary volume of *Science and Public Policy*, was its use of 10-year projections, or scenarios, to support its recommendations regarding the resources required by the U.S. science and engineering enterprise to provide it an adequate basis to assist in addressing national objectives. Perhaps its most significant projection was in the form of a recommendation to double national R&D expenditures during the succeeding 10 years, that is, by 1957 (Stelman 1947, vol. I, 13, 26). In 1947, total U.S. R&D expenditures were estimated to be slightly more than \$1 billion. (See text table 1-4.) According to this scenario, national R&D expenditures should reach an annual level of \$2 billion—or 1 percent of national income (that is, Gross Domestic Product, GDP)—by 1957, requiring greater increases in public than in private spending.

The report went on to recommend explicit functional targets for Federal R&D expenditures to be achieved by 1957: 20 percent for basic research, 14 percent for research in health and medicine, 44 percent for nonmilitary development, and 22 percent for military development (Stelman 1947, 28).

### Basic Research Support

Basic research was singled out as the principal arena for concerted Federal action by both *Science—The Endless Frontier* and *Science and Public Policy*. Both reports urged Con-

Text table 1-4.  
Estimated 1947 U.S. R&D expenditure,  
by source and character of work

Source	Total	Basic research	Applied R&D
<b>1947 current dollars (in millions)</b>			
Federal Government			
War and Navy departments ..	500	35	465
Other departments .....	125	20	105
Federal total .....	625	55	570
Industry .....	450	10	440
University .....	45	35	10
Other .....	40	10	30
U.S. total .....	1,160	110	1,050
<b>1998 constant dollars (in millions)</b>			
Federal Government			
War and Navy departments ..	3,295	231	3,065
Other departments .....	824	132	692
Federal total .....	4,119	362	3,757
Industry .....	2,966	66	2,900
University .....	297	231	66
Other .....	264	66	198
U.S. total .....	7,645	725	6,920

NOTE: Details may not sum to totals because of rounding.

Applied R&D = Applied Research and Development

SOURCE: John R. Steelman, *Science and Public Policy* (Washington, DC: U.S. Government Printing Office, 1947). Reprinted by Arno Press (New York: 1980). *Science & Engineering Indicators – 2000*

gress to enact legislation to create a National Science Foundation; the latter recommended that the proposed agency should be authorized “to spend \$50 million in support of basic research its first year ... rising to an annual rate of \$250 million by 1957” (Steelman 1947, 31–2).

### Defense Research

OSRD’s wartime achievements were based in large measure on the active participation of nongovernment civilian scientists and engineers in all aspects of military R&D, from planning through implementation. Vannevar Bush was determined to maintain civilian involvement, and in some cases even civilian control, over the most critical defense-related research projects in the postwar era. “Military preparedness,” as *Science—The Endless Frontier* argued, “requires a permanent, independent, civilian-controlled organization, having close liaison with the Army and Navy, but with funds direct from Congress and the clear power to initiate military research which will supplement and strengthen that carried on directly under the control of the Army and Navy” (Bush 1945a, 33). That is, Bush took the position that defense research policy should be an integral component of overall Federal research policy.

By August 1947, a special task force of the Defense Research Board (which Bush chaired) in the newly created Department of Defense was preparing its own report and recommendations so that the Steelman Board excluded itself from any detailed examination of defense research, other than to recommend that more weight should be given to nondefense research than was the case in 1947.<sup>29</sup>

### Human Resources for Science and Engineering

The development of scientific talent was of particular concern in the late 1940s. World War II had demonstrated that the availability of adequate numbers of well-trained scientists and engineers, rather than a lack of financial resources, was the limiting factor in undertaking or completing essential research projects. The war itself had led to what both reports referred to as a severe “deficit” in trained scientists and engineers resulting from the fact that young people who would have obtained degrees in science and engineering had been prevented from doing so as a result of their service in the Armed Forces. Many trained scientists and engineers had also been among the casualties of the war. *Science and Public Policy* emphasized that, unless and until these deficits were corrected, the U.S. research enterprise could not use significant additional funding to maximum advantage.

In 1947, there were an estimated 137,000 scientists, engi-

neers, and technicians engaged in R&D and/or teaching. Among these, 25,000 had Ph.D.s in the physical and biological sciences (Steelman 1947, vol. I, 15–8). During 1941, the number of Ph.D.s awarded in the physical and biological sciences had reached a peak level of 1,900. By comparison, fewer than 800 Ph.D.s were awarded in these fields during 1945. Although the number of Ph.D.s awarded had risen to approximately 1,600 by 1947, *Science and Public Policy* estimated that the rate of Ph.D. conferrals in science would have to increase to 3,800 per year by 1957 to provide adequate human resources for the Nation.

Both *Science—The Endless Frontier* and *Science and Public Policy* recommended that the Federal Government should support a substantial program of scholarships at the undergraduate level and fellowships at the graduate level to alleviate these human resource deficits. *Science and Public Policy* argued that Federal aid should not be limited to students in science and engineering. Rather, it should be part of a more extensive Federal Government program designed, in part, to relieve wartime deficits in other areas as well.

*Science and Public Policy* emphasized that the condition of science education at the primary and secondary levels was an essential determinant of the health of the U.S. science and engineering enterprise. Volume IV, devoted entirely to human resources issues, included an analysis of the results of an extensive survey, entitled “The Present Effectiveness of Our Schools in the Training of Scientists,” commissioned from AAAS (Steelman 1947, 47–162). The AAAS report dealt with the entire mathematics, science, and engineering education system from the primary grades through graduate school.

*Science and Public Policy* also recognized that the working conditions of scientists and engineers could have a decided impact on their productivity and, therefore, on the condition of the U.S. research enterprise. Accordingly, it commissioned a detailed survey on attitudes of government, industry, and academic scientists toward their work from the National Opinion Research Center at the University of Denver (Steelman 1947, vol. III, 205–52).

### Role of the Federal Government

World War II having ended, it was generally agreed that the bulk of the Nation’s R&D performance would once again—indeed should once again—take place outside of the government. On the other hand, it was increasingly clear that the Federal Government’s role in the national R&D enterprise had become indispensable. There was a broad consensus that its direct role should include support for research in its own laboratories, provision of funds for basic research in universities and for university facilities, and a scholarship and fellowship program for promising young scientists and engineers. Additionally, the Federal Government should monitor the condition of science and technology in the country and seek means to encourage partnerships among the industrial, academic, and Federal Government research sectors to meet essential national goals. There was much less unanimity on the extent to which the Federal Government should be involved

<sup>29</sup>The task force, chaired by Irvin Stewart, formerly executive assistant to the director of OSRD and at that time president of the University of West Virginia, issued its report, entitled *Plans for Mobilizing Science*, in 1948. Because of objections by high level Pentagon officials, it did not reach President Truman’s desk until shortly before the start of the Korean War. One of the charges to William T. Golden as special consultant to the White House was to determine the applicability of the Stewart report in the environment of the Korean War.



in the support of nondefense applied research or civilian development.

### Internal Government Coordination

Consistent with President Truman's charge in establishing PSRB, *Science and Public Policy* documented in detail the Federal Government's rapidly expanding science and technology programs, noting that they were dispersed across many agencies with little or no coordination among them, except by means of the annual budget process managed by BoB. As one means to improve this situation, it recommended that an interagency committee should be established "to secure maximum interchange of information with respect to the content of research and development programs" and that the Federal Government's role with respect to the national science and technology enterprise should be monitored continually to obtain "an over-all picture of the allocations of research and development functions among the Federal agencies" (Steelman 1947, vol. I, 61).

The report went on to emphasize that science policy issues might often require attention at the highest levels of government. Accordingly, it asserted that "There must be a single point close to the President at which the most significant problems created in the research and development program of the Nation as a whole can be brought into top policy discussions" (Steelman 1947, vol. I, 61).

### International Dimensions

The U.S. scientific community was eager to reestablish international communication and information exchange that had been disrupted by World War II. Types of Federal assistance suggested by *Science—The Endless Frontier* and *Science and Public Policy* included funding travel to international scientific meetings, encouraging visits to the United States by outstanding foreign scientists, supporting translations of foreign journals, and awarding international fellowships. *Science and Public Policy* predicted that "the future is certain to confront us with competition from other national economies of a sort we have not hitherto had to meet" (Steelman 1947, vol. I, 4). Despite this, it went on to argue that it was in the national interest to lend "every possible aid to the re-establishment of productive conditions of scientific research and development in all those countries [of Europe and Asia] willing to enter whole-heartedly into cooperation with us" (Steelman 1947, vol. I, 5). The report suggested that such aid might include assistance in the reconstruction of research facilities in Europe as a component of the Marshall Plan, which had been proposed two months before its release.<sup>30</sup> It also suggested several more modest measures, including international fellowships for U.S. science and engineering students and more experienced investigators to work abroad, and a program for shorter term visits by senior U.S. researchers to allow them to reestablish international connections interrupted

by World War II. Reciprocally, it recommended that U.S. universities should be encouraged to admit qualified foreign science and engineering students, particularly into their graduate programs (Steelman 1947, vol. I, 38–40).

Looking into the future and beyond the principal prewar scientific powers, the Steelman report noted that:

Currently great progress is being made in India in the construction of new scientific research laboratories and in the training of hundreds of first-rate research workers.<sup>31</sup> In the same way Chinese scientific development may be expected to go forward rapidly, and great progress is being made in our neighbor American Republics (Steelman 1947, vol. I, 41).

In short, *Science and Public Policy* took the view that U.S. science policy should be based on a long-term view, particularly with regard to its international dimensions, and that what it tacitly assumed would be short-term problems in other countries should not be allowed to obscure the rising importance of science on a global level.

## Monitoring the Condition of the Science and Engineering Enterprise

### "A Program for the National Science Foundation"

*Science—The Endless Frontier* and *Science and Public Policy* had both envisioned a science policy implemented in a genuine peacetime context, albeit with due regard for national security needs. As it happened, the final elements of the U.S. Government's science and technology organization were put in place during the early stages of the Cold War. NSF was created barely six weeks before the start of the Korean War on June 25, 1950, and the first protopresidential Science Advisory Committee, established on April 19, 1951, was created as a response to the Korean crisis on the recommendation of William T. Golden.

As background for the report on science and national security that the White House commissioned in September 1950, Golden interviewed a wide range of scientists, military experts, and politicians, including Bush, Steelman, and three prominent scientists whom President Truman had nominated as members of the first NSB on November 2, 1950: Detlev W. Bronk, a biologist who was president of The Johns Hopkins University and of the National Academy of Sciences (NAS); James B. Conant, a chemist and president of Harvard University; and Lee A. DuBridge, a physicist and president of the California Institute of Technology.

While the main purpose of Golden's interviews was to determine whether in view of the Korean crisis an organization similar to OSRD should be created, he frequently inquired as well about the role that the newly created NSF should play among other agencies of the Federal Government. Golden summarized his conclusions in a February 13, 1951, memo-

<sup>30</sup>Secretary of State George C. Marshall announced the intention of the United States to provide funds for the reconstruction of Europe's infrastructure in an address at the Harvard University commencement on June 7, 1947.

<sup>31</sup>The first volume of the Steelman report was released less than two weeks after India achieved its independence from Great Britain on August 15, 1947.